Claims

1. A method of testing a seismic brace for connecting an object to a fixed structure, comprising:

applying a load to the brace in cycles simulating the forces due to an earthquake.

2. The method of claim 1, wherein the load is applied to the brace in approximately 15 cycles.

3. The method of claim 1, wherein the brace has a stiff main member, a building-attached component for connecting the main member to a fixed structure, and an object-attached component for connecting the main member to an object to be braced, said building-attached component and said object-attached component having insignificant stiffness relative to the stiff main member, and

the step of applying comprises applying the load in cycles to the building-attached component and to the object-attached component, the load being applied to the components independently of one another.

4. The method of claim 3, wherein the load is applied to each of the building-attached component and the object-attached component in approximately 15 cycles.

5. The method of claim 3, wherein the component has an orientation with respect to vertical when the component is in use in the brace, and the method comprises applying the load to the component in said orientation and at an angle with respect to vertical.

6. The method of claim 5, wherein the step of applying is repeated for a plurality of building-attached components identical to one another and for a plurality of object-attached components identical to one another, the load being applied to one of the building-attached components and one of the object-attached components at an angle of 30° to vertical, to another one of the building-attached components and another one of the object-attached components at an angle of 45° to vertical, to yet another one of the building-attached components and yet another one of the object-attached components at an angle of 60° to vertical, and to still another

one of the building-attached components and to still another one of the object-attached components at an angle of 90° to vertical.

7. The method of claim 3, further comprising:

determining a maximum permissible deformation, due to applying the load in cycles, for the building-attached component and for the object-attached component;

measuring the forces applied to the building-attached component and the object-attached component by the applying of the load in cycles;

plotting said forces versus the deformations of the building-attached component and the object-attached component that the forces cause; and

determining from the plot the load ratings of the building-attached component and the object-attached component.

8. The method of claim 6, further comprising:

determining a maximum permissible deformation, due to applying the load in cycles, for the building-attached components and for the object-attached components for each angle at which the load is applied;

measuring the forces applied to the building-attached components and the object-attached components by the applying of the load in cycles;

plotting said forces versus the deformations of the building-attached components and the object-attached components caused by the forces; and

determining from the plots the load ratings of the building-attached components and the object-attached components.

9. The method of claim 7, wherein the step of determining a maximum allowable permissible deformation due to applying the load in cycles comprises monotonically applying a load in both tension and compression to the building-attached component and to the object attached component, the load being applied monotonically to the components independently of one another;

measuring the forces applied monotonically to the building-attached component and the object-attached component in both tension and compression;

plotting the forces applied monotonically versus the deformations of the building-attached component and the object-attached component caused by the forces applied monotonically to obtain data curves;

selecting for each component, the data curve, either the data curve plotted for the tension load or the data curve plotted for the compression load, that has the gentler slope, the gentler slope indicating the flexible loading direction; and

estimating from the selected data curves the deformations, due to applying the load in cycles, that the building-attached component and the object-attached component can resist.

10. The method of claim 9, wherein the step of determining a maximum allowable permissible deformation due to applying the load in cycles further comprises

applying the load in cycles to each of a) a building-attached component identical to said building-attached component and b) an object-attached component identical to said object-attached component such that deformations in the components equal the deformations estimated in the estimating step;

from the forces corresponding to the deformations applied in cycles, determining the minimum force for each component; and

plotting the minimum forces versus the estimated applied deformations corresponding to the minimum deformations.

11. The method of claim 1, wherein the load is applied in cycles to a first sample of the brace, the method further comprising applying a load monotonically to a second sample of the brace that is substantially identical to the first sample.

12. The method of claim 11, further comprising additional applying steps each involving a respective brace identical to said brace, wherein the load applied monotonically is applied in a respective one of a plurality of directions, each defining an angle with respect to the longitudinal axis of the brace.

13. The method of claim 1, wherein a maximum permissible deformation is assigned to the brace, and the monotonically-applied force required to achieve the maximum permissible deformation is measured.

14. The method of claim 3, wherein the cycles are applied in a frequency of approximately 0.1 Hz where the component is nonfriction based and 3 Hz where the component is friction based.

15. The method of claim 11, wherein the step of applying a load monotonically comprises applying an increasing load monotonically in tension to a first sample of the brace until either the brace fails or deformation of the brace exceeds a predetermined permissible maximum, applying an increasing load monotonically in compression to a second sample of the brace identical to the first sample until the brace fails or deformation of the brace exceeds a predetermined permissible maximum.

16. The method of claim 15, wherein data curves comprising values of the increasing monotonically applied force and associated values of deformation, one data curve each for tension and compression, are plotted on force-deformation coordinates, wherein one data curve has a more gradual slope than the other, and wherein the point δ_1, along the data curve having the more gradual slope, that corresponds to approximately one-third of either the predetermined permissible maximum deformation or the deformation at failure δ_1 is determined from the plot, and the force F corresponding to the point is determined from the plot.

17. The method of claim 16, further comprising determining from the plot the point on the less gradual data curve that has a force equal to the force F, and determining from the less gradual data curve a deformation δ_2 that corresponds to the point on the less gradual data curve having a force equal to the force F.

18. The method of claim 17, further comprising subjecting a third sample of the brace substantially identical to the first sample to approximately 15 cycles of loading to a deformation of δ_1 in the direction, either the tension direction or the compression direction, with which the

more gradual data curve is associated and to a deformation of δ_2 in the direction with which the less gradual curve is associated.

19. The method of claim 18, wherein the third sample is subjected to approximately 15 cycles of loading at a frequency of approximately 3 Hz for a friction-based brace and approximately 0.1 Hz for a nonfriction-based brace.

20. A method of testing a component of a seismic brace for connecting an object to a fixed structure, comprising:

applying a load to the brace component in cycles simulating the forces due to an earthquake.

21. The method of claim 20, wherein the load is applied to the brace component in approximately 15 cycles.

22. The method of claim 20, wherein the component has an orientation with respect to vertical when the component is in use in the brace, and the method comprises applying the load to the component in said orientation and at an angle with respect to vertical.

23. The method of claim 22, wherein the step of applying is repeated for a plurality of components identical to one another, the load being applied to one of the components at an angle of 30° to vertical, to another one of the components at an angle of 45° to vertical, to yet another one of the components at an angle of 60° to vertical, and to still another one of the building-attached components at an angle of 90° to vertical.

24. The method of claim 20, further comprising:

determining a maximum permissible deformation, due to applying the load in cycles, for the component;

measuring the forces applied to the component by the applying of the load in cycles;

plotting said forces versus the deformations of the component that the forces cause; and

determining from the plot the load ratings of the component.

25. The method of claim 24, wherein the step of determining a maximum allowable permissible deformation due to applying the load in cycles comprises

monotonically applying a load in both tension and compression to the component;

measuring the forces applied monotonically to the component in both tension and compression;

plotting the forces applied monotonically versus the deformations of the component caused by the forces applied monotonically to obtain data curves;

selecting the data curve, either the data curve plotted for the tension load or the data curve plotted for the compression load, that has the gentler slope, the gentler slope indicating the flexible loading direction; and

estimating from the selected data curve the deformation, due to applying the load in cycles, that the component can resist.

26. The method of claim 20, wherein the load is applied in cycles to a first sample of the component, the method further comprising applying a load monotonically to a second sample of the component that is substantially identical to the first sample.

27. The method of claim 26, further comprising additional applying steps each involving a respective component identical to said component, wherein the load applied monotonically is applied in a respective one of a plurality of directions each defining an angle with respect to the longitudinal axis of the brace.

28. The method of claim 20, wherein a maximum permissible deformation is assigned to the component, and the monotonically-applied force required to achieve the maximum permissible deformation is measured.

29. The method of claim 20, wherein the cycles are applied in a frequency of approximately 0.1 Hz where the component is nonfriction based and 3 Hz where the component is friction based.

30. The method of claim 26, wherein the step of applying a load monotonically comprises applying an increasing load monotonically in tension to a first sample of the component until either the component fails or deformation of the component exceeds a predetermined permissible maximum, applying an increasing load monotonically in compression to a second sample of the brace identical to the first sample until the component fails or deformation of the component exceeds a predetermined permissible maximum.

31. The method of claim 30, wherein data curves comprising values of the increasing monotonically applied force and associated values of deformation one data curve each for tension and compression are plotted on force-deformation coordinates, wherein one data curve has a more gradual slope than the other, wherein the point δ_1, along the data curve having the more gradual slope, that corresponds to approximately one-third of either the predetermined permissible maximum deformation or the deformation at failure δ_1 is determined from the plot, and the force F corresponding to the point is determined from the plot.

32. The method of claim 31, further comprising determining from the plot the point on the less gradual data curve that has a force equal to force F, and determining from the plot the deformation δ_2 that corresponds to the point on the less gradual data curve.

33. The method of claim 32, further comprising subjecting a third sample of the component substantially identical to the first sample to approximately 15 cycles of loading to a deformation of δ_1 in the direction, either the tension direction or the compression direction, with which the more gradual data curve is associated and to a deformation of δ_2 in the direction with which the less gradual curve is associated.

34. The method of claim 33, wherein the third sample is subjected to approximately 15 cycles of loading at a frequency of approximately 3 Hz for a friction-based component and approximately 0.1 Hz for a nonfriction-based component.